

# Going green in Germany

Putting a century of expertise into practice with hydrogen as a transport fuel

By Stephen B. Harrison

Driving in Germany is perhaps best known for the absence of speed restrictions on parts of the German Autobahn network. And German car makers are renowned for their top-tier luxury brands. More recently, there has been another good reason to pay attention to the German road transport sector: the way it is embracing hydrogen mobility.

At now 82 hydrogen filling stations in operation at the time of writing, the German network sits up there alongside the Japanese and Californian systems as a beacon that will light the way to lower transportation emissions. No other European country can boast a similar network and approximately two thirds of Europe's hydrogen filling stations are in Germany. However, when it comes to hydrogen-fuelled cars, the story is different.

Japanese and South Korean car makers Toyota and Hyundai lead

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the league table when it comes to sales of fuel cell hydrogen-powered production models with their Mirai and Nexon cars. Hyundai's monthly fuel cell electric vehicle (FCEV) sales regularly top 3,000 units and Toyota also regularly sells more than 2,000 hydrogen-powered cars each month. Whilst the Asians clearly lead here, the German auto industry is also innovating in this direction.

The unveiling of the Mercedes GLC F-Cell at the Frankfurt Motor Show in September 2017 was a key milestone for the European luxury brand. Two years later, BMW revealed its pre-production BMW iHydrogen Next, also at the Frankfurt Motor Show.

Beyond hydrogen-powered FCEVs, the German auto sector is no stranger to battery electric vehicles. For example, in November 2019, Elon Musk was in Berlin to announce that Tesla will build batteries, powertrains and vehicles, starting with Model Y in the new 'Gigafactory 4', close to Berlin. Battery electric vehicles (BEVs), not hydrogen...but certainly an important move in the broader German electromobility scene. Also in November 2019, VW re-confirmed its strategic focus in the electric vehicle race to be the production of BEVs for the masses.

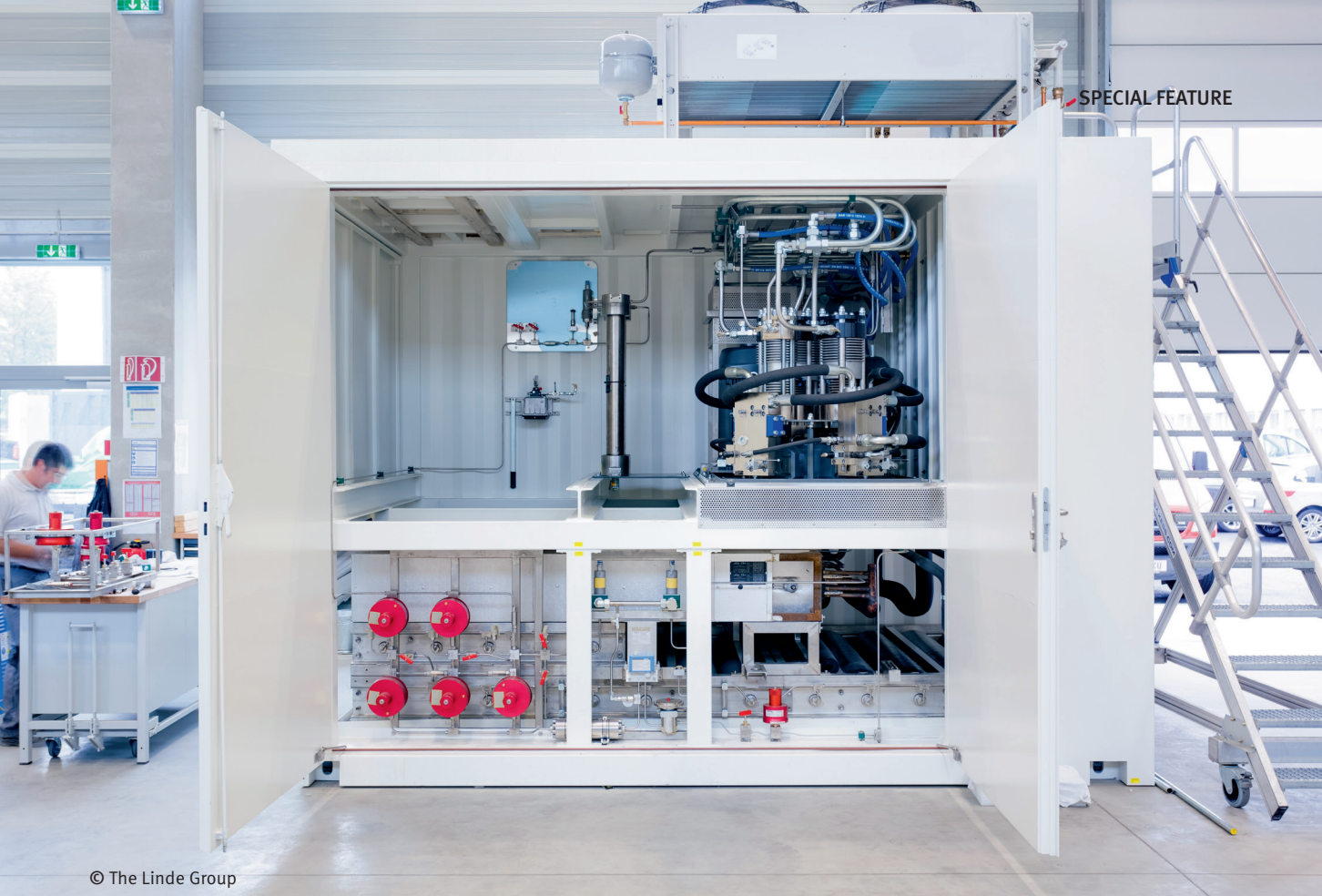
**Ready to serve the new Berlin airport**  
After several years of delays, it is hoped

that the new Berlin-Brandenburg airport at Schönefeld will open in October 2020, later this year. Cars and taxis delivering passengers to their flights and other airport vehicles will be able to fill up with hydrogen at the Total Multi-Energy fuelling station there.

That project was completed by several companies working in partnership, including Linde and McPhy Energy Deutschland. McPhy delivered a 0.5 MW electrolyser to the project.

Christopher Braatz, Business Development Manager at McPhy in Berlin explains the way the electrolyser fits into the hydrogen value chain for this project. “Wind and solar energy are used to produce electricity for the local power grid. The electrolyser draws on this power to produce hydrogen. Since these natural energy sources fluctuate with the weather conditions and the demand profile for hydrogen over a 24-hour period is variable, there is a hydrogen buffer storage system between the electrolyser and the hydrogen car fuelling station.”

“Excess hydrogen can also be fed to the local natural gas grid to enrich that fuel stream with a low-emission hydrogen gas. It can also be fired in a compact CHP plant located on the filling station site. Or, Linde have installed a hydrogen collection point onsite where they can decant hydrogen



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from the storage and transport it in road tankers and deliver it to other users nearby.”

#### **Environmental and economic sense**

The electrolysis process that produces hydrogen and the fuel cell that converts stored hydrogen back to electrical power both yield low-grade heat.

To make the overall hydrogen production, storage and power regeneration energy balance more favourable, it is advantageous to re-use this warmth for constructive purposes. For example, on a public fuelling station the heat can be used in the car wash and site facilities. This is exactly what McPhy Energy Deutschland is doing at its latest large hydrogen electrolyser project in Laage, northern Germany. A 2MW electrolysis unit there will be installed to produce hydrogen. In the first phase, the gas will be used to fuel buses for a local bus operator. In a second phase, a road-side hydrogen fuelling station will be added for private cars.

Turning again to Braatz, he comments that, “the main reason for using hydrogen as a fuel in transportation to replace diesel and petrol is environmental sustainability. So, the idea of waste heat recovery is fully aligned to the overall concept. It also makes economic sense: local factories and properties need heating energy at moderate temperatures which is exactly what the electrolyser and fuel cell yield.”

#### **Putting a century of expertise into practice**

Building on a foundation of handling energy carrier gases such as town-gas and hydrogen, Linde embodies the skills required to add value to the hydrogen economy. Today, The Linde Group offers a range of leading technologies along the entire hydrogen value chain: this goes from production, liquification, transportation, storage of hydrogen to finally application of hydrogen in various segments, including transportation.

A thread that they all have in common is to increase the safety, efficiency and reliability of hydrogen supply. With more than 180 stations built worldwide, Linde is the most experienced manufacturer and installer of hydrogen refuelling stations. Translating that to the needs of everyday transportation, it means that the hydrogen refuelling infrastructure that Linde has developed has enabled more than 1.5 million refuelling events for fuel cell-powered cars, buses and forklifts.

Linde Hydrogen FuelTech, a 100% affiliate of Linde Engineering, is the entity within The Linde Group fully dedicated to bringing the hydrogen molecule into fuel cell vehicles in the most efficient and reliable way through specially engineered equipment. Dr. Werner Ponikvar, Managing Director Linde Hydrogen FuelTech GmbH, is responsible for Linde’s hydrogen fuelling equipment strategy including R&D, manufacturing, commercialisation, project execution ►

► and aftersales service. He says, “As we cast our minds forward into this new decade, we are convinced that we have the right mix of partners to continue our leadership role. For example, our 20% investment in the Yorkshire-based ITM Power and the foundation of a joint venture with ITM for power-to-gas projects (ITM Linde Electrolysis) for more than 10MW are clear signals that this is an area of strategic importance for our company.”

Focusing on the transport hydrogen infrastructure in Germany, Linde installed more than 70 hydrogen fuelling stations – larger and smaller ones – and 32 public stations for light fuel cell vehicles in partnership with H2 Mobility Germany, and more than 40 privately operated stations for busses, fork lifts, cars and test facilities. Linde is a founding member of H2 Mobility, the organisation which operates all public hydrogen refuelling stations in Germany.

Together with other big names from Germany, Austria and further afield, such as Daimler, OMV and TOTAL, H2 Mobility is a successful collaboration of industrial gases suppliers, oil and gas majors and automotive OEMs. The multi-disciplinary model is currently being used as a blueprint for the development of other leading and emerging hydrogen mobility markets such as Japan and Korea.

### Shades of green and grey

In addition to its investment in ITM power, Linde owns a 10% stake in Hydros spider, a producer of ‘green’ hydrogen from hydro-electric power in Switzerland. Its flagship is the 2MW electrolyser at Alpiq’s Gösgen power station near the town of Olten on the river Aare. The electrolysis plant can produce up to 300 tonnes of hydrogen per year, which is enough to keep approximately 50 trucks or 1,700 cars on the road.



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On the topic of green hydrogen, Dr. Ponikwar states that, “Linde is committed to make emission-free hydrogen widely available and easy to use. Producing hydrogen via electrolysis powered with renewable energy for fuelling stations is the must-be-scenario for the future.

“More and more customers demand ‘green’ hydrogen for their fuelling stations. We have already realised numerous systems that meet this requirement and we always offer fuelling stations with integrated electrolysis technology. However, most stations today are still supplied with hydrogen produced from natural gas in a steam methane reformer. As a transition step towards full sustainability, we regard this as acceptable, especially considering that an FCEV fuelled with ‘grey’ hydrogen emits 30% less CO<sub>2</sub> well-to-wheel compared to a state-of-the-art internal combustion engine car.”

“For the time being, we believe that the reliable and plentiful availability

of hydrogen it is of paramount importance. This will ensure that fuelling stations can be operated reliably at a reasonable cost for drivers and means that automotive OEMs can invest in the development and commercialisation of fuel cell vehicles in the knowledge that the fuel will be affordable and accessible.”

With industrial gases companies, such as Linde, entering the transportation fuels production and distribution sector, some might ask whether there is either the potential for conflict, synergy or collaboration with the established transportation and energy majors. Is this a grey area? Ponikwar has a clear answer to that question. He says that, “for the time being, we find ourselves in a nascent and dynamic market situation and the industry needs to develop the market, technologies and infrastructure.”

“Against this background, our experience is that every serious, proactive player in the hydrogen mobility market is welcome.” **sw**

### ABOUT THE AUTHOR

Stephen B. Harrison is celebrating 30 years involvement in industrial gases this year.

He was previously global head of Specialty Gases & Equipment at Linde Gases, and spent more than 15 years with BOC Gases. He is now a consultant.